Q. 21.

After t seconds, Alberto has travelled

$s_1 = 12t + \frac{1}{2}t^2$

After t seconds, Gustav has travelled $s_2 = t^2$

At both P_1 and P_2,

$$s_1 = s_2 + 22$$

$$12t + \frac{1}{2}t^2 = t^2 + 22$$

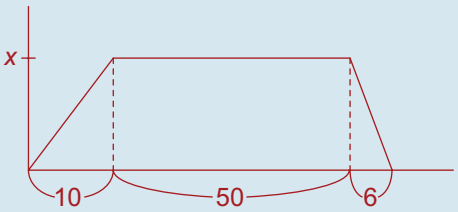
$$t^2 - 24t + 44 = 0$$

$$t = 2, 22$$

Answer: (i) After 2 seconds

(ii) After 20 seconds more

Q. 22.



Area under the curve = 696

$\frac{1}{2}(10)x + 50x + \frac{1}{2}(6)x = 696$

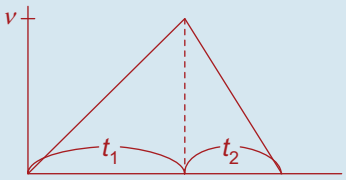
$$x = 12$$

$v = u + at$

$12 = 0 + a_1(10)$

$a_1 = 1.2$ m/s^2

Similarly, $a_2 = 2$ m/s^2



$t_1 : t_2 = 2 : 1.2 = 5 : 3 = \frac{5}{8} : \frac{3}{8}$

$\therefore t_1 = \frac{5}{8}T, \quad t_2 = \frac{3}{8}T$

$v = u + at$

$v = 0 + (1.2)\left(\frac{5}{8}T\right) = \frac{3}{4}T$

Area = 696

$\frac{1}{2}(T)\left(\frac{3}{4}T\right) = 696$

$$T^2 = 1{,}856$$

$$T = 8\sqrt{29}$$

Q. 23. Take speeds, accelerations, distances relative to the goods train.

Let p = the passenger train and g = the goods train.

The initial relative speed,

$u_{pg} = u_p - u_g$

$= 80 - 30$

$= 50$ m/s

The relative distance = 1,500 m

The final relative speed is zero, since the two trains must eventually be travelling at the same speed to avoid a crash.

$v^2 = u^2 + 2as$

$0 = (50)^2 + 2a(1{,}500)$

$a = -\frac{5}{6}$ m/s^2

The relative deceleration is, therefore,

$\frac{5}{6}$ m/s^2

The actual deceleration of the passenger train is $\frac{5}{6}$ m/s^2, since the goods train does not decelerate at all.

Q. 24. (i) Initial relative speed,

$u = 20 - 8 = 12$ m/s

Relative distance = 120 m

Final relative speed = 0 m/s

$v^2 = u^2 + 2as$

$0 = (12)^2 + 2a(120)$

$a = -\frac{3}{5}$ m/s^2

(ii) (i) $u = 12$

$a = -1$

$s = 120 - 66 = 54$

$t = ?$

$s = ut + \frac{1}{2}at^2$

$54 = 12t + \frac{1}{2}(-1)t^2$

$t^2 - 24t + 108 = 0$

$(t - 6)(t - 18) = 0$

$t = 6, 18$

Answer: After 6 seconds